EXAMINED abs.
IMP. BUR.
26 JUN. 1917
ENTOM.

BULLETIN No. 188 MARCH, 1916

ALABAMA

Agricultural Experiment Station

OF THE

Alabama Polytechnic Institute

AUBURN

Boll Weevil in Alabama

By
W. E. HINDS, Entomologist.

1916
Post Publishing Company
Opelika, Ala.

COMMITTEE OF TRUSTEES ON EXPERIMENT STATION.

HON. R. F. KOLB ..... Montgomery
HON. A. W. BELL ..... Anniston
HON. J. A. ROGERS ..... Gainesville

STATION STAFF

C. C. THACH, President of the College.
J. F. DUGGAR, Director of Experiment Station and Extension.

AGRICULTURE:

J. F. Duggar, Agriculturist.
E. F. Cauthen, Associate.
M. J. Funchess, Associate.
J. T. Williamson, Field Agt.
R. U. Blasingame, Agr. Engr.
O. H. Sellers, Assistant.
H. B. Tisdale, Assistant.
F. E. Boyd, Assistant.

VETERINARY SCIENCE:

C. A. Cary, Veterinarian.
L. F. Pritchett, Assistant.

CHEMISTRY:

J. T. Anderson, Chemist, Soils and Crops.
C. L. Hare, Physiological Chemist.
C. A. Basore, Assistant.

JUNIOR AND HOME ECONOMICS EXTENSION:

L. N. Duncan, Supt. *
Miss Madge J. Reese, Asst. *
J. C. Ford, Assistant. *
I. B. Kerlin, Assistant. *

BOTANY:

W. J. Robbins, Botanist.
A. B. Massey, Assistant.

PLANT PATHOLOGY:

————, Pathologist.

HORTICULTURE:

Ernest Walker, Horticulturist.
J. C. C. Price, Associate.
————, Field Agent.

ENTOMOLOGY:

W. E. Hinds, Entomologist.
F. L. Thomas, Assistant.
E. A. Vaughan, Field Asst.

ANIMAL INDUSTRY:

G. S. Templeton, Animal Husbandman.
H. C. Ferguson, Assistant.
J. P. Quinerly, Assistant.
E. Gibbens, Assistant.

* In co-operation with United States Department of Agriculture

BOLL WEEVIL IN ALABAMA

By

W. E. Hinds, Entomologist.

WEEVIL SPREAD THROUGH ALABAMA.

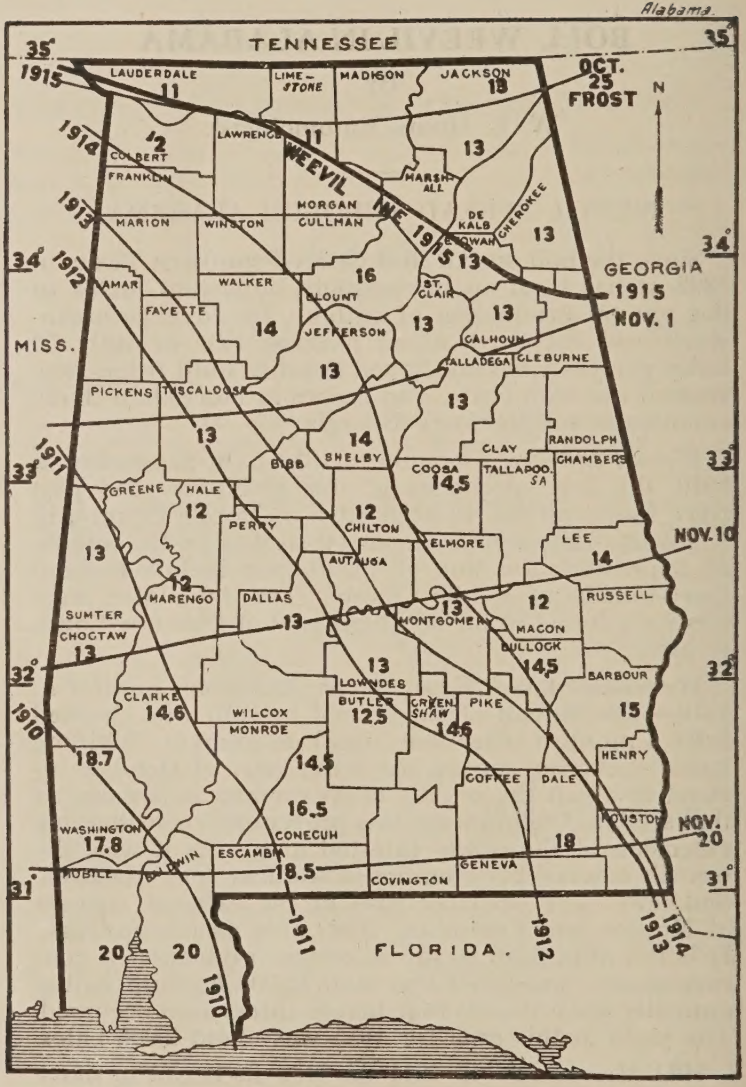
Since the boll weevil first entered southern Texas in 1892, it has been an increasingly important factor in our annual production of cotton. Its advance northward and eastward, at an average rate of fully 50 miles per year, has continued steadily until it has now crossed our own State, and occurs in more than thirty counties in southwestern Georgia.

Weevil Entered Alabama in 1910.—On September 3, 1910, the first specimens of this much dreaded pest were found on the western edge of Mobile County, in Alabama. The weevil advanced so that by the middle of September the line of infestation included about three-fourths of Mobile County. Ten days later, weevils were found in the southern part of Choctaw County also.

Weevils Entered Six or Seven Alabama Counties in 1910.—The spread of the weevil in 1910 was checked fully a month earlier than usual on account of killing frosts occurring during the latter part of October instead of about the middle of November as is usual in that section. Undoubtedly this prevented a considerable extension of the newly infested area. As it was, the weevils entered five counties in southwestern Alabama, and may have occurred also in the extreme corners of Monroe and Escambia. This area (see map, Plate I) is not important so far as cotton production is concerned as it produced less than 15,000 bales of cotton annually upon the average before infestation occurred. The yield in this area for 1915 was about 2,000 bales.

1911 *Movement.* In 1911 the weevils began to move about the middle of August and continued until killing frosts occurred about the middle of November. This advance brought 12 Alabama counties, wholly or partly, within the infested area. The movement was very evidently checked by the formation of immense numbers of squares, following the stripping of the plants by the September generation of cotton worms.

PLATE I.



WEEVIL ADVANCE IN ALABAMA, SUMMER RAINFALL AND AVERAGE DATE OF FIRST KILLING FROST.

Lines running diagonally from Northwest to Southeast show weevil advance from 1910 to 1915.

Figures within county lines show normal total rainfall during June, July and August.

Lines running nearly East and West show average date for first killing frost.

Degrees of latitude are shown on the margins. (Original.)

1912 *Movement.*—The actual number of weevils surviving the winter of 1911-12 was very greatly reduced below the usual average survival by three especially important factors: (1) The unusual period of hot, dry weather which continued for about two months in the early summer of 1911. (2) The general stripping of cotton throughout Alabama and other infested states by the cotton leaf worms (*Alabama argillacea*) during the fall of 1911. This stopped the fall multiplication of weevils by destroying or preventing the formation of their only possible breeding places and gave us the finest possible demonstration of the value of a general practice of the early fall destruction of stalks as a method of weevil control (see pp. 47-55). (3) By the unusually severe winter weather in 1911-12. The weevils reached Coffee and Geneva counties this season, making an advance of about 75 miles in south-central Alabama.

1913 *Movement.*—Extremely early frosts occurred on the mornings of October 20 and 21, almost a month earlier than the average date for first killing frosts in this State, and extended along practically the entire line of weevil advance. Some sheltered localities escaped killing temperatures, but as a general rule the advance was checked about that time. Largely on account of the short season for their spread, the weevil advance averaged only between 20 and 25 miles.

1914 *Movement.*—Again, unusually early killing frosts put an early stop to the advance of the weevil. In the southern part of Alabama, the weevils were very effectively controlled during the early summer by an unusual period of hot, dry weather. In many localities where the weevils had been for two years, practically none were seen until after the middle of July when more rain fell. Thereafter weevils multiplied so rapidly that in spite of the early control, little cotton was made after the middle of August. On account of this unusual combination of summer climatic conditions, cotton in the southern third of the State put on an extremely heavy top growth through August, September and October. This furnished the weevils developing after July, with an abundance of uninfested squares and bolls right in the fields where they developed and there was, consequently, no necessity for such widespread dissemination as usually occurs after August 15. These facts may fully explain the failure

of the weevils to advance in southeastern Alabama as they would usually have done.

1915 *Movement Greatest Ever Known.*—Killing frost occurring generally throughout North Alabama about November 15 put a stop to further advance of the boll weevil in that section for 1915. This is about three weeks later than the average date for killing frost in the Tennessee Valley and gave the weevils opportunity to spread somewhat farther than they could have done in an average season.

The advance of the weevil for 1915 covered more new territory than in any season since it entered Texas in 1892. In the fall of 1914 the weevil line passed through Houston County, Alabama, within a few miles of the Chattahoochee Valley. The infestation of Houston County, however, occurred so late in the season of 1914 that the weevils failed to maintain themselves beyond the eastern part of Geneva County, where they were found scatteringly in the early summer of 1915.

Early in September, 1915, traces of boll weevil work were discovered in the vicinity of Thomasville, Georgia, which was beyond the distance that the weevil would normally have reached by the end of the season. Immediate investigations in Georgia and Alabama revealed the fact that a remarkable movement of the weevil had occurred, apparently between the 20 and 23 of August. This movement had carried the weevils for more than 140 miles in an eastwardly and northeastwardly direction beyond the 1914 line in Alabama. Throughout this newly infested territory, the infestation evidently began at practically the same date, as weevil stages, eggs and grubs, found 100 miles away were as old as those found only a short distance beyond the 1914 line. A similarly great advance was made by the weevils into western Texas and central Oklahoma where more than 25 counties were invaded for the first time.

Spread By Winds.—An examination of the Weather Bureau records in Alabama revealed the probable explanation for this unusual movement in this eastern section. It is found in a heavy wind from the West and Southwest which occurred on August 20, following the severe storm at Galveston, Texas. Weevils do not take flight in a heavy wind but if caught by strong wind currents high above the surface they may be carried for long distances and the greatest advance

movements appear to have been due to this wind factor.

Alabama Nearly All Infested.—Only five counties in northeastern Alabama now lie outside of the weevil infested area and they are quite certain to become infested in the fall of 1916. The weevils are now in southwestern Tennessee; Mississippi is all infested and they have crossed the Tennessee Valley in this State. The complete infestation of Alabama cotton fields must be expected by the fall of 1917 at latest.

Quarantine Regulations Nearly Past.—As the weevil advances, the quarantine line against it must move forward accordingly. No restrictions whatever apply now in Alabama to shipments of cotton seed or other products, household goods, etc., within the weevil infested area. All boll weevil quarantine regulations will therefore soon be a thing of the past so far as any shipments destined to any Alabama points are concerned but the regulations of other states must still be observed to continue the fullest possible protection for their uninfested territory.

The Fight Must Be Made Now.—All cotton planters within this infested area in Alabama should plan to take up the fight against the boll weevil immediately, even if they have not yet been forced to do so by severe weevil injury. Avoid the loss sure to follow if cotton culture be continued in the usual way. Cotton can still be grown profitably and yields may be even increased, where the summer rainfall is less than 14 inches, by the immediate adoption of the improved methods which are described in this bulletin.

Damage Largely Preventable.—The advent of the weevil is a fact of the utmost importance to the cotton planters of Alabama. Only by immediately adopting and putting into practice part or all of the methods which have been found most effective in controlling the weevil in Texas, Louisiana, Mississippi and other states can the planters of Alabama avoid passing through the same experience of loss as planters have suffered in previously infested territory. These methods have been thoroughly tried and have proven practical and effective. It is the object of this and other publications of the Alabama Experiment Station to show exactly what methods should be adopted and how the damage done by the weevil to cotton may be reduced as much as is possible. The following para-

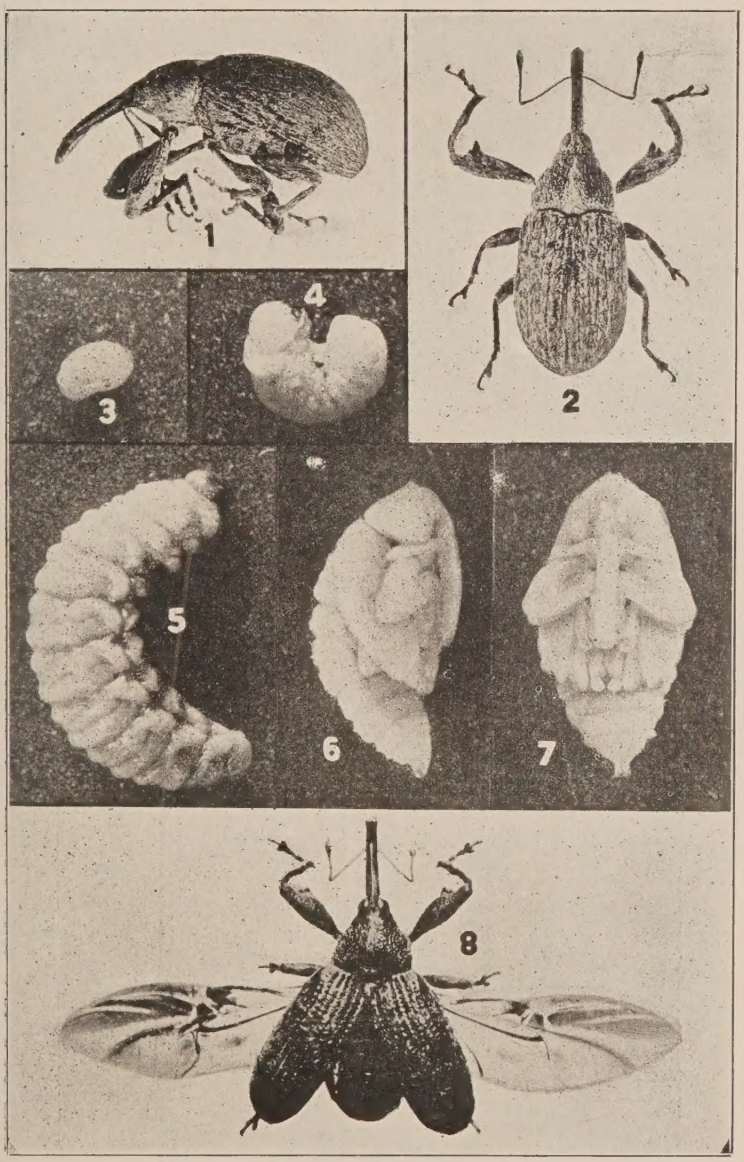
graphs briefly describe the different stages of the weevil as they are found in cotton, and outline the life history so that the reason for the effectiveness of many of the practices advised may be evident to the intelligent reader. By following these suggestions closely the damage which the boll weevil will necessarily inflict may be reduced to a small part of what it will do if its presence is ignored and old methods of cotton production are continued.

STAGES AND WORK OF THE BOLL WEEVIL.

The Boll Weevil Attacks Cotton Only.—The boll weevil is a beetle belonging to a large group all of which have a part of the head in front of the eyes greatly extended to form a long, slender snout. There are many hundreds of species of these insects, all of which are commonly called "weevils," but the Mexican cotton boll weevil is the only one attacking cotton in this country. Another species attacks cotton squares in Peru, South America.

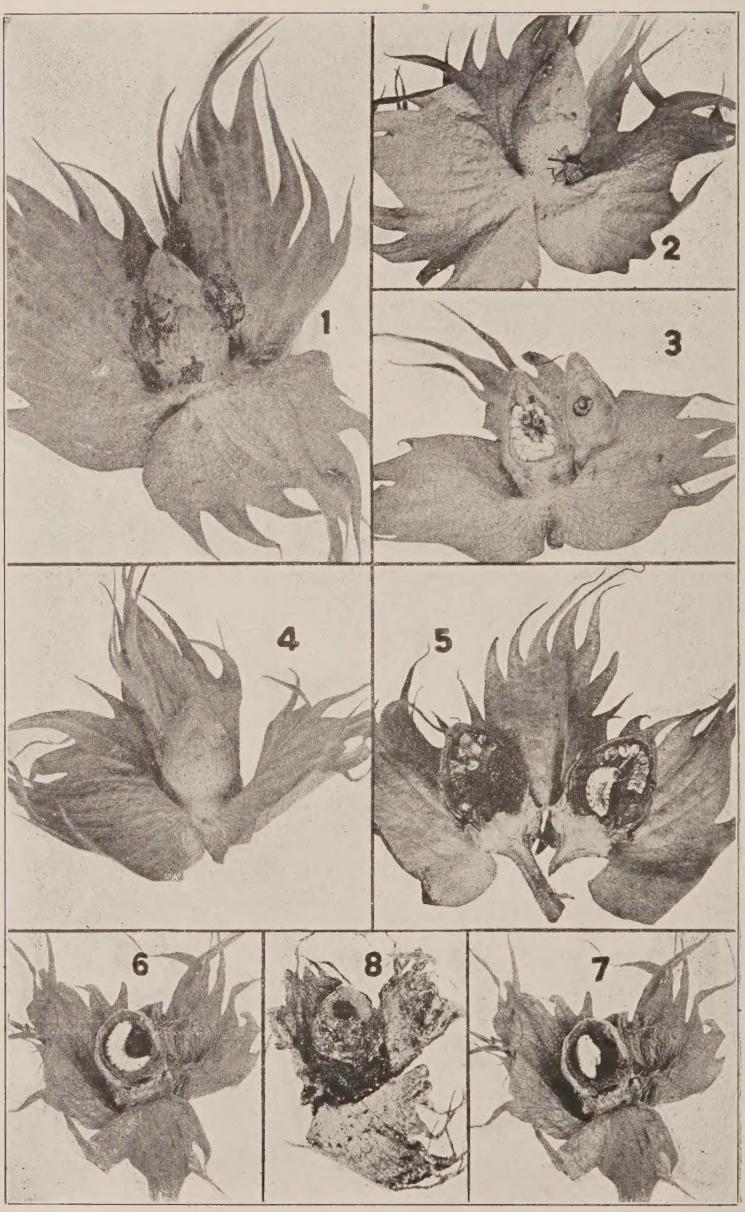
Other Weevils Mistaken For Boll Weevil.—The weevils so commonly found during the fall and winter in the stems and roots of cocklebur, ragweed, etc., are different species entirely. They are often mistaken for the boll weevil. (See Alabama Extension Leaflet No. 10.) The boll weevil breeds in cotton squares and bolls and nowhere else. The species in cocklebur is known as the cocklebur weevil or "transverse Baris" and that in ragweed is the "ragweed weevil." These weevils do not attack cotton and the boll weevil never occurs in these weeds. In the spring a species of weevil which breeds in cowpea pods and is known therefore as the "cowpea pod weevil" is found quite commonly upon young cotton where it does some damage by feeding on the buds and tender leaf stems as does the boll weevil. The cowpea pod weevil is about the size of the boll weevil but is solid black in color and the surface of its body is evenly covered with small pits or dents which give it a very different appearance. This cowpea weevil does not breed in cotton. It is simply feeding there while waiting for cowpeas to develop and then leaves the cotton for the cowpea fields where it occurs during the balance of the season.

Four Stages: 1, *Egg.*—Like all other beetles the boll weevil has four distinct stages in the development of each individual. The first of these is the egg, which



BOLL WEEVIL STAGES.

Figure 1, Adult weevil, side view; fig. 2, adult, viewed from above; fig. 3, egg of weevil; fig. 4, grub at entrance to second stage after shedding first skin, about three days old; fig. 5, grub fully grown, about ten days from egg; fig. 6, transformation or pupal stage, side view, snout, legs and wings forming; fig. 7, pupal stage, front view of fig. 6; fig. 8, adult, wings spread. Figs. 1, 2, 5, 6, 7 and 8 enlarged about ten diameters; figs. 3 and 4, enlarged about twenty diameters. (Original.)



WEEVIL WORK ON SQUARES.

Figure 1, Adults feeding, male head upward, female head downward; fig. 2, orange-colored masses of excrement, work of young weevil; figure 3, interior of feeding puncture; fig. 4, egg puncture in usual position; fig. 5, grub half-grown at falling of squares; fig. 6; full-grown grub; fig 7, transformation from grub to beetle occurs within squares; fig. 8, emergence hole made by weevil escaping from square. All natural size. (Original.)

is only about 1-30 of an inch long, white and very delicate. Plate II, figure 3. Eggs are always deposited in cavities which the female eats in the squares or bolls and nowhere else upon the cotton plant, and never in any other common plant.

2. *Grub.*—From the egg there hatches in a few days a white, legless grub or worm which does not at all resemble the beetle which it may finally become. The grub of the boll weevil, (Plate III. figures 5 and 6 ,and Plate IV, figures 4, 5, 6, 7, 8.) resembles very closely the "worms" found in peaches and plums, but those are the grubs of another species of weevil, known as the plum curculio. The boll weevil grub grows steadily from a length of about 1-25 of an inch when it hatches until it becomes fully grown and measures 1-5 to 2-5 of an inch in length, Plate II, figures 4 and 5. The largest grubs are produced in large bolls, Plate IV, figures 6 and 8.

3. *The Pupa.*—In order to attain the beetle form the grub must pass through an intermediate "transformation stage", which is known as the "pupa". In this stage no food is taken, and there is a complete change of the appearance and of structure. The grub sheds its skin and instead of the legless, wingless, snoutless "worm", the pupa appears with all of these organs forming in sheaths closely applied to the body. Plate II, figures 6 and 7. In this stage the insect is very delicate, and perfectly helpless. It, as well as the egg and grub stages, is passed wholly within the interior of the square or boll, Plate III, figure 7; Plate IV, figure 9. These three constitute the immature stages in the life of the weevil, but are as characteristic of the species as is the adult form.

4. *Adult.*—After a few days the pupa sheds its skin and becomes the fully formed adult weevil, Plate II, figures 1 and 2, having the legs and snout free and usable, as are also the wings. The wings when not in use are folded back under, protected and hidden by, the hard wing-covers, which meet in a straight line over the middle of the back of the beetle. For a few days the adult also remains protected within the square or boll while it becomes hardened and more able to care for itself. It then cuts a circular hole just the size of its body in the wall of its cell in the square, Plate III, figure 8, and through this opening makes its escape into the outer world, where from that time on

it leads a free and active life. Weevils escape from small bolls as they do from squares, Plate IV, figure 5, but in large bolls they wait for the boll to mature and crack open before they mature and then have only to cut their way through the wall of the cell in which they have transformed, Plate IV, figure 6.

The adult beetle, found on cotton only, is about 1-4 inch long, including the slightly curved snout which is one-half as long as the rest of the weevil's body. The color is dark brown, ashy-gray, or yellowish brown.

Signs of Injury.—Among the most conspicuous external signs of boll weevil presence and injury are the following: the occurrence of open cavities 1-25 to 1-30 inch in diameter and reaching down to larger excavations among the pollen sacs, Plate III, figure 3 and Plate IV, figures 1 and 2; the presence of "warts" marking the egg punctures of the weevil; the occurrence of the orange-colored excrement of the beetles on the buds, Plate III, figure 2; the abundant shedding of squares and the consequent scarcity of blooms without accompanying temperature, rainfall or cultural conditions to cause the shedding.

HOW WEEVILS SPREAD, MULTIPLY AND PASS THE WINTER.

Weevils Fly.—The full-grown weevils fly, especially during the period from about August 15 to November 15, and their spread into new territory is accomplished almost entirely in this way. The wings, when not in use, are folded under, and closely covered and protected by the hard wing covers that meet in a straight line along the middle of the back of the weevil. As they appear when extended in flight, the wings are shown in Plate II, figure 8.

Multiply in Top Growth.—When female weevils reach new, uninfested territory, they feed for a short time and then begin to deposit eggs at the rate of from 6 to 10 per day, in such squares and small bolls as they can find. The egg puncture, Plate III, figure 4, is sealed up air-tight, after the egg is deposited. Each female may lay several hundred eggs and in the course of three or four weeks a new generation will be produced in this field. These weevils may continue the process so that before frost kills the plants, a large number of weevils will have been developed from the few weevils which flew into new territory. To prevent this breed-

ing, and to control the weevils most effectively and economically, we strongly recommend the practices of producing an early maturing crop of cotton, harvesting as soon as the cotton can be picked out and then immediately turning under the stalks.

Weevils Breed in Cotton Until Frost Kills it.—Weevils are absolutely dependent upon cotton for feeding and breeding. As a rule, the number of weevils in the field is considerably reduced during the period while cotton is opening because the number of available breeding places is then reduced as squares become scarce and most bolls are too large for the weevils to infest them. After the crop is matured, if favorable rains occur, there is usually a considerable growth of late squares with blooms and many small bolls formed. This condition is remarkably favorable for the development of weevils, and the number of weevils increases very rapidly until frost destroys the cotton.

Establishes Species in New Territory.—Migrated weevils, which have flown many miles into new territory, are likely to find just this late growth of squares in which they may reproduce and thus establish the species in the new territory. It is possible for two or three generations to be thus produced before frost. The danger is that planters may not realize the presence of the weevils, as the fields are usually neglected after the cotton is picked out, and thus the conditions most favorable for the weevils are left without a single effort being made to change or remove them. Naturally not as many weevils are likely to be produced during the first season in the new territory as may be found during the fall in older infested fields, but the danger to the crop of the following year may be nearly as great under certain conditions.

Many Thousands of Weevils May Occur on Each Acre of Cotton.—In old infested fields, it is by no means uncommon to find from one to four or five weevils for each plant growing in the field. This means that from five to twenty-five thousand weevils per acre may be found at the time of the first frost. More than 50,000 weevils per acre have been found in the late fall in some cases where careful collections of weevils were made.

Late Developed Weevils Most Likely to Survive.—It is a well established fact that the weevils developing and becoming adult late in the fall are those which

are most likely to survive the winter. They have not exhausted their vitality by long flights or by any considerable reproductive activity, as have older weevils. It becomes doubly important therefore that the development of weevils late in the fall should be prevented as much as is possible.

Hibernate in Adult Stage.—As with most insects, the winter season is passed quietly and without feeding by the full-grown or adult weevils. These seek shelter from the cold in or under any kind of rubbish near where they are feeding when the first frosts occur. After this time they can live for months without any food. This dormant, winter condition of the insect is spoken of as hibernation.

Hibernation Usually Begins At First Killing Frost.—As cool weather approaches in the fall, weevils become less active and some may seek winter shelter even before frost occurs. Most of them, however, continue to feed until green cotton is largely destroyed. The occurrence of the first killing frost is a signal for the great majority of weevils to seek shelter for the winter. This we call entering hibernation. If the freeze is severe enough to completely destroy squares and bolls, the immature stages may be killed at once or some may complete their development and emerge but practically all of these will die before spring as they have never fed.

Hibernation Shelter.—Weevils pass the winter as adults hiding in or under any kind of trash which may be found in or around the cotton field. The old hulls on standing cotton stalks are among the most common places of shelter. Weevils also crawl under leaves and into dense bunches of grass on the ground. Very weedy or bushy places are favorable for weevil hibernation. Ditch banks, terraces, fence rows, timber fringes, stumps in the field, etc., are therefore important places to be cleaned up and cared for where the weevil occurs as this reduces the chances of weevils living through the winter.

Spanish Moss Especially Favorable.—Wherever this long gray moss occurs abundantly near cotton fields it is certain to furnish extremely favorable winter shelter for many weevils. Not only is the percentage of survival large in this moss but the weevils emerge from it unusually late because it keeps them cool in spite of high air temperature outside. This moss grows

only where the winters are mild and the summer atmosphere is exceptionally moist or humid. As a result of all of these influences the presence of Spanish moss has come to be regarded as a very certain indication that heavy weevil damage will occur in that vicinity. In fact, in such sections cotton culture has usually been found so uncertain that it has been largely given up in favor of more certain and profitable crops.

Hibernate Principally Within Cotton Fields.—Under ordinary conditions, few weevils fly to any considerable distance from the cotton fields in search of winter quarters. They have no power of purposely selecting exceptionally favorable shelter conditions. It is well known, however, that during warm days following frosty nights, weevils having little shelter may be again somewhat active and again enter shelter, so that in time the weevils gradually secure the most favorable shelter available. The large majority of weevils find winter quarters in or near the field in which they were feeding when frost occurred.

Standing Stalks Give Most Favorable Shelter For Weevils.—Innumerable experiments have shown that the most favorable conditions for successful hibernation are found in fields in which cotton stalks, with grass, weeds, fallen leaves, etc., are left undisturbed until nearly time to plant the following spring. Under these conditions, the maximum number of weevils will survive, and unfortunately this is the most common practice throughout the infested area.

Under Exceptionally Favorable Conditions Over 40 per cent. of the Fall Weevils May Survive.—A large number of carefully planned and executed experiments has been made to determine the effect of the destruction of green cotton at varying dates in the fall, and the effect of various classes of shelter, upon the survival of weevils. It has been found that the range in survival is sometimes as low as a fraction of one per cent. when conditions are unfavorable, and again as high as between 40 and 45 per cent. where exceptionally favorable conditions and seasons have occurred. It is needless to say that there is very little prospect for successful cotton culture under the latter condition.

Average Survival About 3 per cent.—A close study of the weevil in Texas and Louisiana during a number of seasons and in widely separated localities indicated

that there the average survival was about 3 per cent. of the number of adult weevils present in the field at the time that killing frost occurred. While climatic conditions in Alabama may vary somewhat from those under which this result was found, the winter conditions are no more severe.

Weevils Leave Winter Quarters Gradually in Spring.—Wherever weevils become established in the fall some will come out of winter quarters the next spring and be ready to attack cotton as soon as it breaks ground, but the very last of the weevils leaving winter quarters may not emerge until even as late as the first of July. The period during which weevils are emerging from their winter shelter extends beyond three months. They are therefore ready to attack cotton at any time and can live upon the tender stems for as long as is necessary before squares begin to form.

Breeding Begins in Squares.—As soon as squares appear the weevils concentrate their attacks upon them, feeding and laying their eggs therein. By the middle of August it is likely that the weevils will be so abundant, if nothing has been done to control them, that no further cotton will be set. The period from the setting of squares to the formation of a goodly number of half-grown to three-fourths grown bolls should be made as short as possible and upon the abundance of fruit set during this period depends the cotton crop in weevil infested fields.

Migration Occurs During Fall.—From the middle of August until frost checks their movement, many weevils will fly in search of uninfested squares. This flight constitutes the fall spread of the insect. The spread across Alabama from 1910 to 1915 has been quite fully described in the first portion of this bulletin.

FIGHTING THE BOLL WEEVIL.

Infestation Permanent.—The Mexican cotton boll weevil must be reckoned with in the production of all future cotton crops within the infested area. It is not a passing pest as many may expect it to be. It will continue to be a factor in cotton production in Alabama so long as cotton shall continue to be grown.

Cotton Growers Must Reckon With The Weevil.—Observations as to the effect of the weevil in newly infested territory in reducing cotton production shows

that in sections where the attempt was made to continue cotton raising in the old way, the yield has often been reduced anywhere up to 90 per cent. of the normal crop during the first few years of the weevil's presence. In the sections near the Gulf Coast having 18 or more inches of rainfall in June, July and August, cotton has been practically abandoned. Gradually the methods of raising cotton became adjusted to the necessities of the case. In sections having less summer rainfall, other crops besides cotton are grown increasingly, and the cotton crop has in some sections regained its normal size, especially where the June to August rainfall is less than 12 inches. The last condition of the cotton grower is better than the first, but the path of progress has led through several years of loss and suffering. Through the accumulated knowledge and experience of experts who have been fighting the weevil, and the demonstrations of many thousands of planters, we now know that through much of the infested area the weevil can be controlled and cotton culture continued even more successfully than has been usual in the past. A study of the effect of the weevil upon cotton production may be found in Alabama Experiment Station Bulletin No. 178.

Not A Hopeless Fight. But to continue growing cotton successfully, several improvements in our agricultural practice are imperative. Some of the steps in a reliable system of fighting the weevil successfully will be briefly outlined in this bulletin. This outline cannot even mention many points which might be profitably followed, but is intended to show only the principles and some of the special practices which have proven effective in other sections and which will in time become generally adopted here.

Begin Fight Now.—Shall we not begin this fight at once, rather than first lose a large part of two or three crops and then be forced to adopt these ideas? Do not think that the weevils will fail to find your cotton fields or that they will do any less damage therein than they have done elsewhere under similar conditions of soil, climate, etc., unless you make a better fight against them than has been made generally elsewhere.

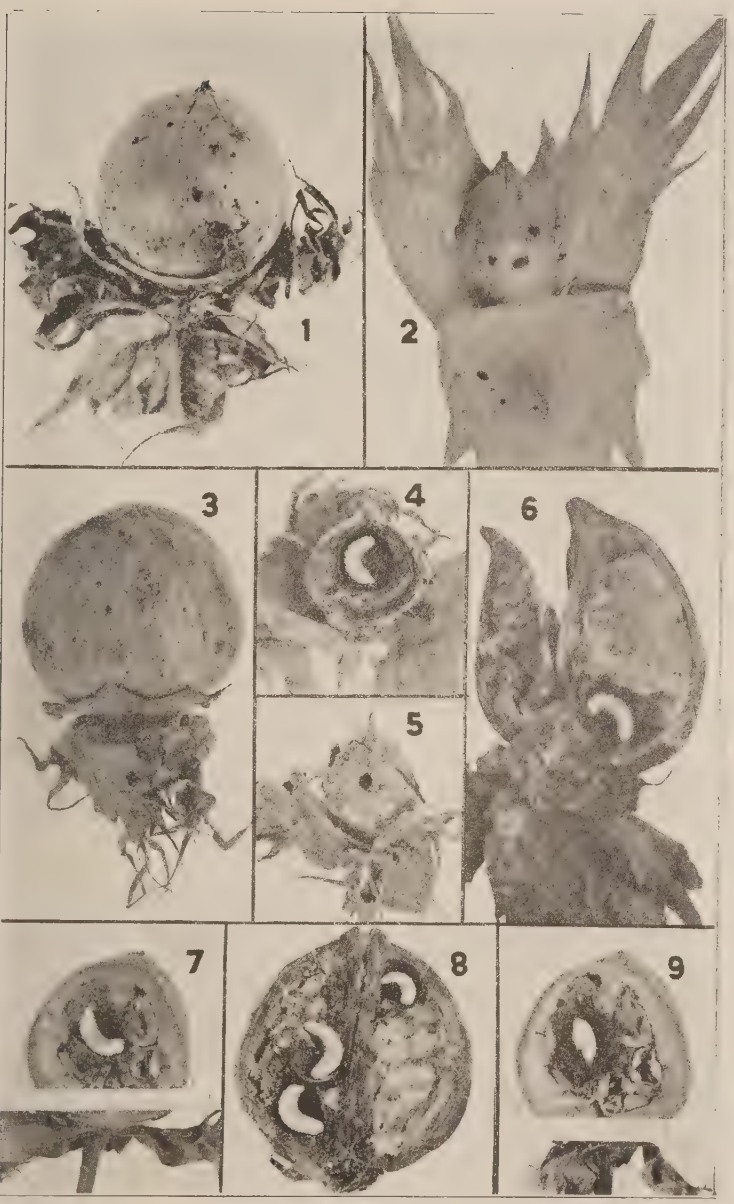
Zones of Injury.—It is true that weevil injury varies in different setions but it is quite fairly constant under the same set of environmental and cultural conditions. Study your own situation and compare it with other

similar sections where the weevil has been for three or more years if you would get a fair idea of the injury the weevil is likely to do in your section. See Plate I. This matter is discussed in Bulletin No. 178.

Summer Rainfall Most Important Factor.—It has been found that boll weevil injury varies quite directly with the amount of rainfall during the three months of June, July and August, as this is the period when cotton is putting on most of the crop. This is the period covered in all cases where rainfall is referred to in the following paragraphs. With a rainfall of more than 18 inches in this period cotton is usually a failure, while with less than 8 inches in these three months, as is the case in western Texas, the weevil is likely to be a negligible factor and may not be able to survive through the season. The average rainfall through the Cotton Belt for these months is 14 inches. In Alabama this 14-inch line passes through Randolph, Chambers, Lee, Russell, Bullock, Montgomery, Crenshaw, Butler, Conecuh, Monroe, Wilcox, Marengo, and Choctaw Counties. On Plate I, the normal rainfall is shown by the figures in each county at approximately the location of the weather recording station.

Southern Third of Alabama Will Lose Half or More of Cotton Crop.—Along this 14-inch line in older infested territory the average decrease in cotton yield, including weevil injury and reduction in acreage, has been fifty per cent. Between the 14-inch line and the Gulf Coast, where the rainfall if from 18 to 20 inches, cotton is bound to be a very uncertain crop, making a fair yield in very dry seasons and liable to be a failure in wet seasons. In this portion of the State the largest degree of change must be made in the whole farming and economic system on account of the weevil. Here we must have the largest reduction in cotton acreage and a portionate increase in other crops, pastures and livestock.

Reducing Cotton Acreage.—No man should attempt to raise more acres of cotton per plow than he is reasonably certain of being able to give all of the extra care that will be demanded under weevil conditions, even if there should be a little more than the average rainfall that is due in his section. Therefore, in the counties along the line of Washington to Henry County and southward, with 16 to 18 inches of summer rain, it is not wise or safe for the average man to try to raise more than 5 acres of cotton per plow. Between this line and a line passing about East and West through



WEEVIL WORK ON BOLLS.

Figure 1, Weevil feeding on three-fourths grown boll; fig. 2, feeding punctures in small boll; fig. 3, two egg punctures in one lock of large boll; fig. 4, grub full-grown in small boll; fig. 5, emergence hole of weevil from small boll; fig. 6, grub full-grown in large boll; fig. 7, grub destroying two locks; fig. 8, several weevils may develop in a boll; fig. 9, pupal or transformation stage in a boll. All figures about natural size. (Original.)

TYPE OF COTTON PLANT FOR WEEVIL AREA.

Fourteen weeks after planting, height of plant 30 inches, spread 30 inches. Evenly and abundantly branched and very short jointed. When photographed had 35 bolls set, several blooms and over 50 squares. Bolls of good size and shape; four and five locked.

Montgomery, having about 14 inches, we would advise not more than 6 or 7 acres per plow where the weevil has been present for more than one year. From Montgomery northward the acreage may be increased at the rate of about one (1) acre per plow for each 35 miles northward, thus allowing about 10 acres per plow in the latitude of Birmingham and 12 acres per plow in the Tennessee Valley.

Only where a man has cleaned up his cotton stalks early the preceding fall or has available an unusually large number of children to help with the summer weevil fight should the foregoing estimates as to safe acreage be materially increased.

Raise a Variety of Crops: Diversify.—The weevils can live only on cotton, but neither the farmer nor his livestock can do this. Our monopoly of cotton raising and the assurance of some crop even with the most shiftless of methods, have been among the greatest curses of our southern agriculture. The effect has been particularly bad during the past fifty years. We cannot continue a "one crop" (cotton) system with the boll weevil present. We can and must raise a variety of crops. This is diversification. Plant especially such crops as can provide food supplies for man and beast on the farm. Stop having to buy and pay big profits to others for the food that you can as well raise at home. Diversification makes it more possible also to use cover crops to build up the soil and make it more productive without depending solely on expensive commercial fertilizers. In no section of the United States can a greater variety of crops be grown than here in Alabama, and we have the added advantage over most of the country of being able to secure from two to four crops each year on the same field.

Plan Your Diversification.—Under these conditions the thoughtful farmer is certain to plan to raise a variety of crops. First, he will plan to raise at home as much as possible of the food supply that may be needed by the family and livestock during the year. Second, he will plan to have some surplus in crops and livestock that can be marketed and, where possible, bring in some cash at intervals during the season so that there will be no need to go into debt. Third, he will plan for such a variety and sequence of crops as will most nearly keep all of his cultivated land occupied and growing something

during every month of the year. Fourth, he will plan for crops that can be handled satisfactorily with the work stock and tools available or obtainable and, fifth, which will tend to conserve and improve the fertility and productiveness of the soil upon which his future prosperity must depend.

Rotate Crops.—According to these plans and purposes of the progressive farmer, and also in order to minimize injury by numerous insect pests (including the boll weevil especially) and fungus diseases, there will be a wise rotation of crops. Cotton will no longer be permitted to follow cotton every year as has been the common practice for the past fifty years.

Increase Humus and Nitrogen.—The vegtable matter in the soil (humus) can be increased and fertility can be improved especially by using such crops as clovers (especially bur or crimson) cowpeas, beans, velvet beans, vetches, etc. The growth of weeds may be prevented and the injury due to both fungus diseases like the boll rot and insect pests such as the boll weevil may be largely reduced by the practice of rotation.

Prepare Soil More Deeply and Thoroughly Before Planting.—The nature and extent of preparation to be given the soil before planting and the cultivation to be given the crop while it is growing become exceedingly important questions in producing profitable crops and especially early maturity in cotton. It is needless to say that the average cotton field is not "worked," it is barely "scratched." The results of innumerable experiments and the practical experience of all of the most successful planters prove that deeper plowing with more thorough working of the soil before planting is one of the first principles in any more successful system of agriculture. Deep plowing should generally come in the fall but thorough spring preparation is also essential to best results with most crops.

Cotton Crop Must Be Made Rapidly.—No principle has been more clearly established than this. Successful cotton crops in weevil infested territory must be made rapidly. The multiplication of the weevil is so rapid that after the third generation becomes adults there is little chance for more bolls to be set. The presence of the weevils absolutely prevents any "top crop," and usually makes the raising of "late cotton" practically an impossibility.

Early Planting Alone is Not Enough.—More things are involved in making a good crop of cotton early than merely early planting of the seed. That alone is not enough to secure success. It is not so much a question of any date on the calendar or of "planting extra early," as it is of reducing as much as possible the time between the first formation of squares and the development of an abundance of bolls to a size at which they are practically resistant to weevil attack. With most varieties of cotton weevils cannot puncture and successfully deposit eggs in bolls that are more than two-thirds grown. The thicker the hull the earlier in its growth does it become immune to attack.

Varieties of Cotton For Weevil Conditions.—First of all we may emphasize the fact that there is no "one best variety" of cotton for all conditions. There are many good varieties and from this list the cotton planter should select such as best suit his conditions. The real basis finally is that of actual experience, of the demonstrated ability of a variety to produce the best yields under the best agricultural conditions that the farmer is able to maintain.

Wilt Resistance of First Importance in Some Sections.—Wherever cotton wilt or black root occurs commonly the quality of "wilt resistance" must be the first considered in selecting cotton seed for wilt territory. Several very good varieties have been developed by individuals and by state and government agents. Write the Director, Alabama Experiment Station, Auburn, for information about these.

On soils giving naturally a small plant, it does better to use varieties of cotton which are naturally of larger than average growth. On such soils these varieties may be hastened in maturity and will not produce such heavy foilage as to favor weevil multiplication as they are likely to do on rich soils. Among these varieties are such as Triumph, Cook's Improved, Wannamaker's Cleveland, and others of similar type.

For Rich Lands.—Here we would choose some of the smaller growing, more prolific types of cotton which will not produce too large a weed with its dense shade, while the size of the bolls is somewhat increased. There are many of these so-called "early maturing," prolific varieties from which choice may be made. King's Improved and many selections from original King stock such as Simpkins, Broadwell, etc. etc.

Characters to Avoid in Cotton.—Avoid both extremes in the matter of branching of the plant. On the one hand, the "limbless" or "cluster" varieties hold all infested squares and do not permit them to fall to the ground where the weevil stages might be destroyed in large numbers by the heat of the sun. The small amount of shade produced is therefore of no advantage. This retention of infested squares favors a larger percentage of development among weevil stages within and the close grouping of squares facilitates more rapid and abundant infestation by the weevils which do not have to travel far from one square to another. On the other hand, the long-jointed, rank-growing varieties produce both a maximum of shade which keeps the sun from exerting its possible control and they also set a minimum of fruit in the period required to produce three generations of weevils. Therefore, the weevils can often destroy all squares on such cotton as fast as they are formed. The result is liable to be a complete failure in the crop with such rank, late-growing varieties. A good type of plant is shown in Plate V.

Plant as Early as Soil and Air Conditions Are Favorable.—It is a well known fact that moderately early planted cotton commonly yields better than that planted late. Extremely early planting is hardly desirable or advisable. The object is to have the plant grow off rapidly and steadily, so that the fruiting may be abundant and the period from squaring to the real making of the crop may be as brief as possible. Plant then as early as soil and air conditions become favorable for the rapid and continuous growth of the cotton. The date for this will vary in different seasons and in different sections of the State.

Uniform Date For Planting Desirable.—It is an advantage to have all cotton in a locality reach the squaring condition at approximately the same date. Weevils cannot begin to reproduce until squares form. If one field in a locality forms squares a month earlier than does another nearby field it will produce a generation of weevils which may spread to the later field and injure it very seriously before it can set its crop. Thus while the earlier field may produce a fair yield, the later field may produce nothing. A difference of three weeks in date of planting in adjoining fields has been seen occasionally to make all the difference be-

tween a yield of two-thirds of a bale per acre and an absolute failure. Where all fields in the locality develop together the weevil finds no such advantage for its multiplication and must therefore do less injury.

Late Planting Inadvisable.—Do not be misled by newspaper "letters" advising late planting to "starve out" the over-wintered weevils. The writers of such letters are usually sincere men who have an idea that this plan should be effective. They do not happen to know what has been found repeatedly to be the fact: That while a few weevils will come from their winter quarters and be looking for food even before the earliest planted cotton will break ground, many will not stir to seek food before the latter part of June or even the first of July. Extremely late planting, with the idea of starving out the over-wintered weevils is therefore doomed to failure and should never be attempted. This has been tested many times and has always resulted in loss.

Cultivate Often And About one and one-half Inches Deep.—Cultivation of the crop should be shallow and frequent. Its first object is to retain moisture and to keep the ground in a favorable condition for the growth of the plants. The destruction of grass and weeds is accomplished incidentally. The surface of the ground should be stirred at least every week during the growing season to a depth of about 1 1-2 inches. Where the weevil is found the crop should not be "laid by" as early as usual, but cultivation continued two or three weeks longer if possible to get through the row without much breaking of the plants. This may well be continued until cotton begins to open.

Use Chain Drag or Cultivator.—In Press Bulletin No 78 of the Alabama Experiment Station, will be found an illustration and description of a very simple home-made implement which can often be utilized to excellent advantage not only in giving an ideal type of shallow, surface cultivation, but also in checking the multiplication of the weevils during periods of hot, dry weather. The arrangement of the chains is such that they draw the fallen infested squares from under the shade of the plant to the middle where the heat of the sun may destroy the weevil stages in them.

Pick Weevils When Squaring Begins.—Beside the cultural practices which have been mentioned there are two special steps that are necessary where weevils are

abundant. and especially where the rainfall amounts to more than 4 inches per month. The first of these steps is the hand picking of the hibernated weevils from the young plants at the time that squares begin to form. This step will pay if it is possible to find fifty or more weevils per acre at the time. In some cases more than 2000 weevils per acre have been thus picked and destroyed. The weevils may be crushed as they are captured or dropped into a bottle containing a little kerosene. The conspicuous sign of the presence of weevils at this stage of the cotton is the appearance of small, black, dead leaves in the tender bud of the plant. In this work it is advisable to use the hoop and sack described below.

Destroy Infested Squares.—This step in weevil control is also necessary where weevils abound early in the season, especially where the rainfall is heavy so that the surface soil is moist most of the time or when the air temperature in the shade does not go much above 90 degrees F. as lower temperatures are not likely to kill many of the weevil stages even if the ground is dry. Picking of infested squares should be done thoroughly, taking the evidently injured squares from the plants as well as the fallen squares from the ground. It should be begun within ten days after the appearance of the first bloom in the field and repeated every fifth day for four to six weeks.

For fuller details regarding these two special practices see Alabama Press Bulletin No. 64.

Making Hoop And Sack Outfit.—In the collection of weevils, and also of many of the infested squares, it has been found recently in Louisiana that a simple home-made device, bearing this name, is very helpful. The hoop should be a large, stout, wooden hoop some 20 or 22 inches in diameter, such as may be obtained anywhere from old sugar barrels. The sack may be made of unbleached sheeting, drilling or of Osnaburg duck.

Get a strip of cloth about eight feet long. Double this strip in the middle and sew up each side to make the bag. Two widths of 32 inch cloth will go around a 20-inch hoop, and of 36-inch cloth for a 22-inch hoop. It is advisable to make the sack somewhat smaller at the bottom than at the top. So in sewing, start about six inches in from each bottom corner and run outward gradually so as to make the sack full width at one foot from the top; continue at full width for six inches

PLATE VI.

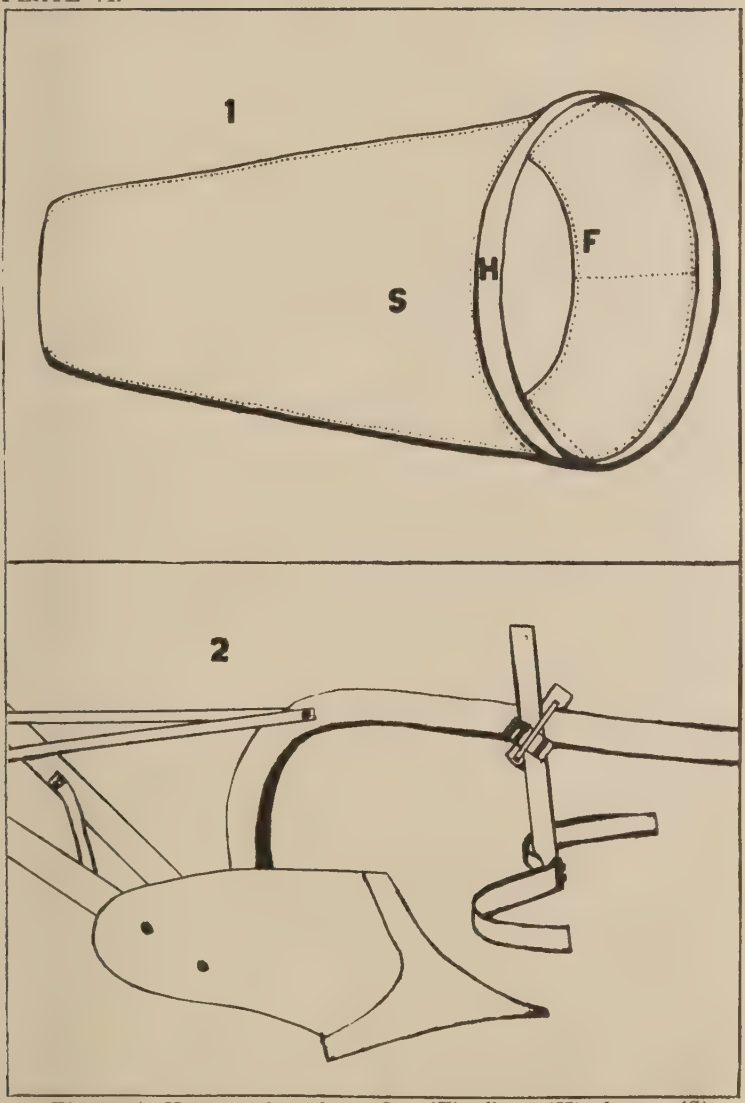


Figure 1, Hoop and sack outfit: (F), flap, (H), hoop, (S), sack. Sew along dotted lines. Fig. 2, Stalk bender, attached to plow beam. (Original).

and then run inward to a point two inches in from the top corner. Next fold the sack with the seams together and take in two more darts at the top corners running from the edge at six inches below the top to two inches in at the top. Trim off the triangular pieces of extra cloth at the lower corners of the sack and at the four darts at the top. Then trim off the top evenly and run a half-inch hem around the top to prevent ravelling and to strengthen the top. After this has been done, place the hoop in position within the top of the sack, folding the cloth down over the hoop so as to make the top form a flaring, projecting flap extending to about six inches below the hoop. The object of this flap is to prevent the weevils crawling out of the sack as readily as they can do if there is no such flap present. Finally, stitch the flap to the side of the sack just below and so as to enclose the hoop. All of this sewing can be done either on a sewing machine or by hand. It will require hardly thirty minutes to make this outfit and the cost will range from 25 cents, if sheeting is used, to about 35 cents with the Osnaburg. A clearer understanding of the construction may be obtained by reference to Plate VI, figure 1.

Using Hoop And Sack Outfit.—Beginning at the time that the first small squares appear, go over the cotton to collect as many as possible of the over-wintered weevils before eggs are laid.

With one hand the hoop is held close against the base of each plant, while with the other hand the plant is bent into the open mouth of the sack and shaken vigorously. A second collection should be made in the same manner about ten days after the first bloom appears and subsequently every five or six days as advised above. With this outfit many infested squares, which are nearly ready to fall, will be shaken into the bag with the weevils and those already on the ground should be collected also. Weevils and squares are kept shaken down into the bottom of the sack where they may be somewhat confined by a turn in the sack. Every few rows the contents of the sack should be emptied into, and submerged in, a tub or barrel containing water with a little kerosene on top. The oil will kill the weevils and the stages in infested squares may be destroyed by burying them later under more than six inches of solidly packed earth. With this outfit a laborer can go over two or three acres of cotton per day and he will probably get many more we-

vils than he could secure by hand picking.

Machines For Collecting Weevils.—A great many machines have been invented, and tested more or less thoroughly, to do this work. None has yet shown itself capable of doing as thorough or economical work as can be done by the hand method, although some of these machines are said to have cost a thousand dollars apiece to build them. Planters will do well to get a disinterested opinion from the Entomologist regarding the merits of any boll weevil machine before investing in one.

Summer Control Difficult and Expensive.—Although no summer practice is nearly as effective as is the early fall destruction of stalks for holding the weevils in check, the measures mentioned may be profitably followed under especially favorable conditions. The deciding factors are usually an available labor supply that costs little if any extra, and a moist condition of the surface soil when squares begin to fall. While it will not often pay to employ hands to collect weevils or to pick up fallen infested squares at even 75 cents per day, it will pay to collect them if the children in the family can do the work. Most cotton squares fall to the ground in about ten days after the weevil eggs are placed in them, and when the grub is about half grown, Plate III, figure 5. In from five to ten days more they may produce adult weevils. If it is very hot and dry and the surface soil forms a dust mulch, fallen squares exposed to the direct sunshine would be "baked" so that all weevil stages in them would be killed. It would not then pay to pick up squares. If done at all, it pays to get the first fallen squares, to pick also all evidently infested squares from the plants and to do the work thoroughly. Naturally these summer methods are much more expensive than the relatively simple matter of early fall destruction of the cotton stalks. The expense of collecting weevils and squares, even with the hoop and sack outfit, ranges usually from $2 to $5 per acre.

Insecticides Not Helpful.—No direct insecticidal practice can be recommended, as it is practically impossible to reach the weevils on account of their peculiar feeding and breeding habits. This is the reason why we must depend upon cultural methods for weevil control. If the cultural methods here outlined are faithfully practiced then there should be little difficulty

in producing increasingly profitable crops of cotton in spite of the boll weevil. Alabama Press Bulletin No. 77 deals with this question of insecticides.

Pick Cotton Promptly.—It should need no argument to prove that cotton should be picked out promptly after it opens. There is nothing to gain and much to lose by allowing it to hang and weather and beat out onto the ground even where there are no weevils. But where weevils occur, prompt harvesting cannot be too strongly urged. This is to clear the way for the early destruction of all green cotton. We cannot even afford to wait for the last few bolls or "scrappings," as this waiting delays the work of destroying stalks and the resultant increased injury to the next crop of cotton from the larger number of weevils that will survive is likely to amount to many times the value of the "scrappings" saved in the fall.

Select Seed For Weevil Resistance.—One of the most important and best paying steps in making larger yields and earlier maturing crops is the careful selection of seed. You cannot afford to continue to plant "gin-run" seed. You may pay fancy prices for high-grade seed to start with, but after a few years without selection and with careless ginning, it will be badly mixed and give much poorer yields. Use your own brain and keep the money in your pocket instead of paying for the use of some other man's intelligence and industry. Get good seed to start with, then select carefully for next year's planting taking the best and earliest bolls from plants of the most desirable type. Remember that this "type" under boll weevil conditions must produce the maximum possible crop of bolls in the shortest possible time after squaring begins, with a foliage that will not shade the ground too heavily. Such plants will usually be of medium size, with numerous fruiting branches and few, if any, vegatative branches. Bolls will be set closely together on the branch and will be "bunched" in closely around the basal and inner two-thirds of the mature plant. These bolls may have thick hulls but in any case should become immune to weevil attack within the shortest possible time after they are set. Hairy stems are also desirable as this character hinders the weevils decidedly in their movements over the plant and therefore delays their working. A desirable type of plant is shown in Plate V.

Prepare to Destroy all Green Cotton as Early as Possible to Save Next Year's Crop.—Having selected seed for next year's planting and harvested the main crop, then the next step in point of time is to starve the adult weevils which can feed only on cotton, and prevent the development of thousands of weevils in the late fall growth of squares and bolls which never can do anything but breed weevils. Do this to save next year's crop. When you cannot possibly raise a top crop of cotton, why raise a bumper top crop of weevils instead?

WEEVIL CONTROL BY EARLY FALL DESTRUCTION OF COTTON.

Stalk Destruction is Usually Possible.—No late maturing cotton occurs where the weevils are abundant. In fact, under weevil conditions the whole tendency is toward the production of a very early maturing crop. With the reduced acreage in cotton, it then happens that the picking season ends, cotton fields can be cleaned up and a winter-growing cover crop may be planted many weeks earlier than such things can usually be done before the weevils arrive. The longer the period between the removal of green cotton plants and the occurrence of killing frost the more complete will be the destruction of the weevils and consequently the less will be the weevil injury to the following crop of cotton. To be fully effective, stalk destruction should occur a month before frost and must include the destruction of squares, bolls and foliage with no chance of sprouts appearing later to maintain the surviving adults until frosts occur.

Most Important Step in Weevil Fight.—Will you choose to destroy the weevils in the fall or have them destroy your cotton crop next year? The earlier stalks are destroyed, the fewer weevils will survive the winter and the smaller will be the damage to the succeeding crop. This early fall destruction of the stalks is the most important single step in the entire fight against the boll weevil. Wherever weevils occur, or may enter new territory, stalks should be destroyed if possible at least a month before frost.

Why Stalk Destruction is so Effective.—There are three principal reasons why early stalk destruction is more effective than is any other practice in directly controlling the boll weevil: First, it completely pre-

vents the late fall breeding. These late-developed weevils are the ones most likely to survive the winter as they have not exhausted their vitality by long flights or by extensive deposition of eggs as have the older weevils. Second, few full-grown weevils can live for more than three weeks without food before killing frosts occur. After frosts the weevils may live for more than six months without tasting food. Early destruction of stalks therefore forces the weevils to move for food to other fields where stalks are still standing or leaves them to starve before it becomes cold enough for them to live without food. Third, cleaning up the cotton fields early in the fall removes the very best winter shelter condition that the weevils could possibly find and therefore reduces directly the percentage of weevils surviving the winter.

The combination of these factors makes the early fall destruction of green cotton the most effective method yet found for fighting the weevil successfully. It is also the most economical method for controlling the weevils as it need not involve any real extra expense.

Records From Texas and Louisiana.—More than 175,000 definite observations made in Texas and Louisiana during several seasons and in a number of widely separated localities gave the results shown below for each 1000 weevils present when their food supply was removed.

All cotton stalks destroyed by	*Number of weevils per thousand surviving winter*
September 30	2
October 15	21
October 31	68
November 16	121

What was found to be true in so large a number of observations, in many localities and in an average of several seasons West of the Mississippi River is doubtless approximately true also here in Alabama and we may therefore expect a similar survival under average winter conditions here.

THREE METHODS OF DESTROYING STALKS.

There are only three methods of stalk destruction to

be considered. They will be mentioned in the order in which they have been commonly practiced, which is, however, the inverse order of their real value.

1,*Grazing Not Recommended.*—First, the grazing off of cotton fields after the crop has been gathered. This practice is old and has been quite generally followed, so far as there was livestock available. The grazing off of weevil-infested cotton fields destroys the stalks only slowly and partially. There is always sufficient green cotton present somewhere in the field to keep alive the weevils that are already adult or which may emerge before frost occurs. The only condition under which grazing can have much value is in the very exceptional cases where the farmer can turn in sufficient stock to graze off all green cotton within a few days time. The grazing method is therefore unreliable, unsatisfactory and cannot be recommended.

2. *Burning of Stalks.*—This method, preferred in the past because no better way was then known, involves the cutting or uprooting, piling and burning of the cotton plants. It has many points of advantage in controlling the boll weevil, but has also the disadvantage of destroying a considerable amount of vegetable matter which is badly needed for building up the soil and increasing its productiveness. For this reason we recommend burning stalks only where weevil control by deep plowing is impossible.

Preparation For Burning to Leave Ground Smooth. – To prepare stalks for burning the farmer may uproot or cut them in several ways. (a) Where a cover crop, such as crimson clover, has been worked in at the last cultivation or before the cotton has been completely picked out, the ground may be left in a smooth, practically undisturbed condition and the cotton stalks removed without injuring the cover crop by simply chopping off the stalks just below the surface of the ground by using sharp, heavy hoes. The stalks may then be piled by hand on the field, or better removed from the field by dragging them off with a hay-rake. One man can chop out the stalks on an acre of average sized cotton in a day. The expense of this method of destruction is therefore not excessive and no extra or unusual tools are required.

A-Shaped Stalk Cutter. -This stalk cutter, described in Alabama Circular No. 33, is arranged to cut two rows at a time throwing the stalks from two rows together

into a windrow. As its efficiency depends upon the maintainance of fairly sharp, cutting edges on the two steel blades that cut the stalks just below the surface of the ground, it is not adapted to use in stony or coarse sandy soil as such soil quickly dulls the knives. It cannot be used conveniently where stumps are very abundant, or on steep hillsides but on fairly level, loamy bottom lands it may place stalks in position for burning more cheaply than it can be done by any other method.

Burn as Soon as Foliage and Tips are Dry.—Stalks to be burned should be placed in position to burn while still green to avoid scattering foliage, squares, bolls, etc. The weevils are then concentrated upon the rows or piles of stalks and nearly all of them will remain there until burning can be accomplished. Burn as soon as the foliage is dry enough to produce a good heat, and while the stalks themselves are still too green to burn cleanly. This saves a considerable part of the vegetable matter. Run the fire along the windrows with the wind to burn as fast as possible.

Burning Destroys Weevils in Several Ways.—Burning stalks destroys weevils in a number of ways. First, it will get immediately a large proportion of the weevils already adult and active. Second, it will absolutely destroy all immature stages in squares and bolls. These stages developing into late weevils would be the ones most likely to survive the winter. Third, by the removal of all green cotton, weevils which escape the fire will be likely to starve to death before they succeed in finding food. Fourth, the destruction of the stalks removes a large proportion of the material which provides most favorable shelter for the weevils during the winter, and weevils still remaining in the field are therefore most likely to perish, or if driven out of the field, less likely to find favorable shelter.

3. *Plowing Stalks Under Early Recommended.* - The best method of stalk destruction, from the combined view point of good farm practice and also of effective weevil control, is to plow the stalks under deeply and completely as early in the fall as may be possible This preserves the full humus-making capacity of the cotton stalks, grass and other vegetable matter that may be present. If buried under four, or more, inches of soil so few weevils will be able to escape that weevil control will be practically complete.

Larger Plows and More Mules Needed.—The old combination of one small and underfed mule, a light plow and an indolent farmer seeking to get along with the least work possible has never produced either an economical or a profitable type of agriculture in the South. Such a combination insures a poor farm and a farmer who is steadily growing poorer. It is important that farmers should accomplish more work at less expense and this they can do by using more mules and better implements. This is a very important matter in making a successful fight against the boll weevil.

Weevils Escape if Plowed Under Shallow.—It is not possible to do a satisfactory job in trying to plow under cotton stalks in the fall with a light, one-mule plow. With such plowing a large proportion of the adult weevils may escape to find food until frost and then hibernate elsewhere. Even the immature stages in squares and bolls buried lightly may mature and the weevils escape under such conditions.

Stalk Chopper Not Necessary for Good Work. It is an easy matter to turn under completely cotton stalks of small size but it has been rather a difficult matter heretofore to do satisfactory burying of green cotton stalks of more than average size. Some farmers have used cotton stalk choppers to cut down the stalks before trying to plow them under. This method involves the extra cost for a rather expensive chopper and an additional operation for a man and two mules in cutting down stalks.

Stalk Bender is Cheap and Effective Attachment to Plow.—The expense thus involved for the chopping of stalks can be saved by the use on the plow of a very simple attachment known as a "stalk bender." This inexpensive device, produced by an Alabama man as a result of the campaign for cotton stalk destruction in the fall of 1915, is a very simple iron attachment, so made that it can be clamped to the beam of any plow in the position ordinarily occupied by the coulter, Plate VI, figure 2. It gathers in cotton stalks or similar growth and bends it flat upon the ground so that the plow-share following closely behind it turns the soil and completely buries the stalks, grass, etc., in the bottom of the furrow. With this device attached to a good two horse plow it is now possible to completely bury the largest cotton stalks without any preliminary use of the stalk chopper. With this device, its cost

may be saved in one or two days of plowing and at the same time an unusually good job of stalk destruction is done. The address of the makers of this stalk bender will be given to anyone requesting it of the Entomologist.

Best Method for Weevil Control in Fall.—The satisfactory burying of green stalks now possible with this inexpensive attachment to the regular plows, the economy in time and labor required, the possibility of preserving all vegetable matter for soil building while at the same time obtaining a very satisfactory fall control of the weevils: these together with other favorable considerations which we have not space to mention here, lead us to recommend the early fall, deep plowing under of stalks with the aid of the stalk bender as the best method now known for the fall campaign against the boll weevil. In our opinion this method avoids the chief objection to the burning of stalks: the destruction of humus-making vegetable matter which most southern soils need very much. It is in line with the best, most progressive and most profitable farm practice of the present time. It will be adopted increasingly by men who own and operate their own lands, by those working under a share rental system and by standing renters who can either make their arrangements by October first or who can arrange for a lease period of more than one year.

Annual Lease a Hindrance.—For the best interests of the land owner who is interested in having the soil in which his capital is invested built up, improved in productiveness, and increased in either sale or rental value, and also of the ambitious renter who desires to increase his income and make a better home, with a better living and better educational opportunities for his family, the annual standing rent lease system is the poorest system imaginable. Under it, we can be certain that practically every tenant is going to take out of the land every thing that he can get and that he will put into it nothing that will not yield him fullest returns the same year. This means a poor system of farming; a depleted, increasingly unproductive soil and lower crop production at greater expense; a poorer farm and a poorer farmer who must keep moving from place to place in a vain search for a better opportunity under a hopeless system.

Clean Up The Farm: Remove The Stumps.—Besides

the destruction of stalks, there are a number of other points included in what may be called clean farming which should be carefully looked after in fighting the weevil. The presence of stumps or dead timber in the field, while bad agricultural practice under any conditions, is especially favorable to weevil hibernation. Dr. S. A. Knapp estimated that the presence of stumps in a field costs the cotton farmer on the average $3 per acre each year. With the boll weevil present, they may cost far more than this, because of the shelter which the weeds, growing around them, may give to hibernating weevils. They cost also by preventing the use of improved machinery, which is especially desirable in boll weevil territory.

Clean Ditches, Turn Rows and Fence Lines.—In general, we would say clean up all kinds of rubbish along ditches, terraces, turn-rows, and around the edges of the field to reduce the chances of weevils hibernating successfully. This will decrease the injury done by other insects besides the boll weevil.

Fall Campaign Most Economical.—From the standpoint of combined effectiveness and economy the early fall is the best time in all the year to make the fight against the boll weevil. We have seen (page 48) that where stalks are destroyed by October first only a fraction over one per cent. of as many weevils will survive the winter as will survive if food is left for them until the middle of November or until killing frosts occur. Therefore, with early fall stalk destruction the weevil fight is made far easier for the following spring and summer. The fall campaign is in line with the best farming methods and will involve hardly any extra expense to obtain effective weevil control. If the fall campaign is not made, then the weevil survival, with average seasonal conditions, will usually make it necessary to pick weevils from the young plants at the time squaring begins (see pp. 41-44) and also to pick and destroy infested squares repeatedly during the first six weeks of the fruiting season (see page 42). The necessary cost for those two admittedly incomplete methods of weevil fighting will usually be at least $3 per acre. In most cases where the fall campaign is made it will be found unnecessary to make this costly summer fight. The direct saving in labor and expense is evident but this is not all. We should also consider the value of the increased yield which

will be obtained as a direct result of the more effective control of the weevil that is obtained from making the early fall campaign.

It Pays to Destroy the Stalks Early in Fall.—From the many demonstrations which have shown the great value of early destruction of stalks in fighting the weevil, we may consider one definite case in which the records were carefully kept and definitely authenticated by the U. S. Bureau of Entomology. On the Gulf coast of Texas in the fall of 1906, all of the planters in an isolated locality, controlling together about 400 acres of cotton, were persuaded to destroy their cotton stalks by burning during the first ten days of October. No cotton was grown nearer than fifteen miles, and here across a bay a suitable check area was found. In the check field stalks were allowed to stand as usual until planters were ready to begin their spring work. Without making any other changes in the practice usually followed by the planters in each of these localities, the yield obtained in 1907, upon the 400 acres averaged better than two-thirds of a bale per acre in spite of the fact that the soil was rather poor and sandy. No weevils could be found in this tract until after the first week in July. Upon the check area hardly one-half of this yield was obtained, although the land here was richer than upon the 400 acre tract. Weevils were abundant on the check area from the time cotton was planted while where stalks were destroyed no weevils could be found until about July 10. The difference in yield can be attributed only to the difference in the manner of handling the stalks the preceding fall.

$20 *Per Acre on* 400 *Acres.*—At the market value of cotton that year, the increased yield upon the 400 acre tract due to fall destruction of the stalks was worth fully $20 per acre, or more than enough to have bought the land upon which the crop was grown. Somewhat similar good results can be obtained anywhere if the fall campaign can be made generally.

Benefit Certain to Man Who Makes The Fight. - Many farmers ask "what good will it do me to destroy my stalks in the fall if my neighbor does not destroy his likewise?" The answer is that the man, farmer A, who makes the fight will receive practically all of the benefit from what he does regardless of the inaction of his neighbor, farmer B. This is true for several rea-

sons. First, weevils escaping immediate destruction in field A, where stalks are destroyed early, can live at that season of the year for only about two weeks without food. They must therefore fly to the undestroyed cotton of the neighboring field B, to find food or they will starve to death before it becomes cold enough for them to live without food. The number of weevils hibernating in or around field A, therefore, becomes negligible while that in field B is increased by weevils coming from A. Second, the winter shelter conditions are most unfavorable for weevils in field A, and most favorable in field B where stalks are permitted to stand. (See page 34). Third, we shall assume that both farmers are likely to plant at about the same time in the spring. Weevils emerging from or around field B will therefore find food close by and very few will therefore go further to reach field A. This is true especially because weevils do not fly in the spring nearly as readily as they do in the fall.

In a most careful study of this matter, using marked weevils, a number of individuals were followed in their movements in a cotton field for more than six weeks in the spring. During this time they had not moved more than fifty yards from the point at which they started. Therefore the movement from field to field is slight as a rule so long as uninfested squares continue abundant where the weevils occur.

Community Cooperation Best.—No man should delay in making the fight because of the lack of co-operation on the part of his neighbors but it is unquestionably better for the whole community if general co-operation can be secured as the danger of an early reinfestation will be correspondingly decreased.

PRINCIPAL FACTORS IN NATURAL CONTROL OF THE BOLL WEEVIL.

Four Groups of Factors.—There are four principal groups which include the most important of all the natural factors of control affecting the boll weevils. As a result of records made by the agents of the U. S. Bureau of Entomology, from the examination of more than 222,000 squares and bolls collected principally in Texas but representing also conditions in Oklahoma, Louisiana, Arkansas and Mississippi, it appears that these four factors are together responsible for the destruction of more than half of the weevil stages that

begin development. In the order of their general importance and with the average percentage of mortality caused by each, they are as follows. 1. Climatic conditions (especially heat and drought in summer), 25 per cent.; (2) Predacious insects ("fire ants" principally), 16 per cent.; (3) Plant resistance by proliferation, 12.5 per cent.; (4) parasites, 4 per cent. Naturally the mortality from heat and predatory ants is greatest among squares and small bolls which fall to the ground. These constitute about seven-eighths of the total number of infested forms. The work of parasites is greatest among the small portion (one-eighth) of forms which remain hanging, but dry up, upon the plant.

These Factors Affect Weevil Injury.—As a direct result of the varying influence of these factors in different sections and during different seasons in the same locality, the direct injuriousness of the boll weevil varies quite widely. Climatic factors affect the growth of the cotton plants as well as the development of the weevils. Conditions of frequent and heavy rainfall, with high humidity and warmth, produce naturally the maximum vegetative growth of cotton, or the largest weed, and also the maximum number of weevils with their consequent maximum direct injury to the cotton yield. Under such conditions the cotton crop is almost certain to be a failure. On the other hand, with a rainfall in June and July especially of less than four inches per month, and if good cultural conditions are maintained so that the plants may continue fruiting steadily, there should be no serious doubt of the possibility of raising a very good crop of cotton in spite of the weevils.

Summer Control by Heat and Drought.—Long periods of extreme heat and drought occurring early in the fruiting season are most effective in checking the multiplication of the weevils. To exert a very marked effect this period must extend beyond four weeks with maximum temperatures, as recorded by the Weather Bureau, ranging above 90 degrees much of the time. During the first month or six weeks after squaring begins, the plants do not shade the ground very much and weevil stages in fallen squares and small bolls may be more certainly destroyed by heat and drying than will be the case later in the summer when the ground is more completely shaded. This matter is quite fully

discussed in Alabama Bulletin No. 178. This summer control will never be as great in Alabama as it is commonly in Texas under their drier summer conditions.

Winter Control by Cold and Wetting.—The other extreme of climatic conditions may also exert a very important limiting effect upon the survival of weevils during their hibernation period. This is most effective, naturally in the extreme northern limit of their range, and in western Texas, Oklahoma and Arkansas especially, has doubtless been the most effective natural factor in limiting the spread of the weevils. Occasionally severe winter conditions seem to have reduced the infested area but in no case has this winter extermination of weevils been as widespread or important as in the case of summer control by summer heat and drought. As a general rule winter conditions of unusual severity simply reduce the number of weevils living through without really exterminating the species and it is not possible therefore to measure accurately the real value of such a control factor.

Winter Temperatures Endured by The Weevils. From a study of Weather Bureau records for many years, it is quite evident that in western Texas, Oklahoma and Arkansas especially, the boll weevil has continued to exist, though in reduced numbers, in territory where the minumum winter temperature has fallen occasionally even slightly below zero Fahrenheit. This does not mean that boll weevils can survive actual exposure to zero temperature, as the shelter within which they are passing the winter may so modify the outside temperature that the actual survivors do not experience a temperature lower than 12 or 15 degrees above zero, F. Certainly where the winter minimum rarely falls lower than 10 degrees F. it may be expected that the weevils will survive the winter in considerable numbers. The records for Alabama show that during the past 24 years the winter minumum for the State has fallen below zero only in seven years and then it has been usually only in the extreme northwestern corner or in the northern portion of the State.

Weevils Now Exist North of Alabama-Tennessee Line.—For several years now the weevils have maintained themselves at points which are farther north than any point in Mississippi, Alabama or Georgia and with the somewhat milder winters that occur in these states, it is evident that there is no good reason to ex-

pect that boll weevils will be unable to maintain themselves generally in even the northern-most portion of these states. Furthermore, we must face the fact that the boll weevil has shown a wonderful ability to adapt itself to colder climatic conditions as it has spread northward from Mexico through fully ten degrees of latitude. This adaptation may, in time, enable the weevil to survive in sections that it has not yet infested.

Cotton Worm Stripping Controls Weevils.—The effect of the cotton worm upon the boll weevil is a very interesting illustration of insect inter-relationship. Both of these species are confined entirely to the same food plant, cotton, although they attack different portions of the plant. They do not in any way attack each other directly, except that where stripping is complete the worms may consume squares which happen to be infested by the weevil. Either species occurring alone is rightly considered a serious pest upon cotton, but when the two species occur together, after half or two-thirds of the squares are infested by the weevils, the cotton worm becomes one of the most effective natural agencies controlling the multiplication of the boll weevil in the fall and thereby greatly reducing the number of weevils occurring the following summer. The benefit is not to the present, but to the succeeding crop and the cotton worm in boll weevil territory should not be poisoned after the boll weevil has infested half of the squares present but considered as a valuable friend and ally of the cotton farmer.

Proliferation in Squares and Bolls.—In response to the irritation or injury inflicted by the weevil to squares and bolls, there commonly occurs a very rapid formation of new cells in the effort of the plant to heal the wounds caused by the weevil. This process of cell formation is called proliferation. These new cells are thin-walled, large cells which form a soft, almost gelatinous mass and this condition may spread to a considerable distance from the point of attack and may ultimately affect the entire square or boll. The large, soft cells are sometimes formed so rapidly and abundantly that the mass exerts considerable pressure, even bursting through the walls of the affected forms. It thus happens that the weevil eggs may be crushed before they hatch or if they hatch, the grubs or pupae, and sometimes even the newly formed adult stages, will be crushed and destroyed by this abundant prolif-

eration. This plant factor is generally responsible for the destruction of about 12 or 13 per cent. of all weevil stages starting to develop and is therefore one of the most important natural factors in weevil control. Proliferation commonly extends beyond, and exceeds by its own injurious effects, the direct injury which might have been caused by the weevil stage which started it. The abundance of this proliferous cell formation appears to vary with different varieties of cotton and also in the same variety under different conditions of soil moisture.

Predacious Ants Helpful Insects.—About thirty other insect species feed more or less upon some stage of the boll weevil. The most important predatory enemy is the little "fire ant" which occurs already distributed through the cotton belt. These ants occur on most types of soil but not everywhere in equal abundance. Where they are numerous they may exert a very valuable control effect upon the boll weevil. These ants are partly, at least, carnivorous and learn to cut their way into the fallen infested squares especially and there feed upon the helpless, tender grubs and pupae of the boll weevil. Occasionally these ants have been found to destroy more than half of the weevil stages in fallen, infested squares but as a rule their control ranges between 12 and 20 per cent. The holes made by ants entering squares resemble superficially the exit holes made by weevils as they emerge but a close examination of the interior of the weevil cell shows that, where ants have entered, the cell is left practically clean and empty. On the other hand when the weevil has emerged there will be left in the cell the remains of shed skins from the weevil stage as it transformed, some conspicious white particles of excrement voided by the weevil before it ever fed and the fine material torn away by the weevil as it formed the emergence hole through the wall of its cell and the square. Many other species of ants do a similar but less common good work and a number of other insects feed occasionally upon either adult or immature stages of the weevil.

Parasites Are Not Dependable.—More than twenty-five different species of insects and four species of mites are known to attack the boll weevil as true parasites. These parasites have other native hosts and simply include the boll weevil as it comes within their range. Parasites attack more commonly the weevil

stages in squares and small bolls which dry up but remain attached to the plants. Naturally parasitism may increase somewhat as the weevil infestation becomes older but in no section have the parasites ever shown ability to control the boll weevil practically under natural conditions in the field. Parasite multiplication must necessarily follow that of its host. Their occurrence is always uncertain and cannot be determined by the ordinary cotton grower. The parasites like the predacious insects must be considered by the farmer as his friends and helpers but he can never afford to neglect the certainty of control by cultural methods for the uncertain and remote possibility of control by any natural enemies. As a general thing parasites have accounted for less than six per cent of the boll weevil stages.

Birds.—More than fifty different species of birds have been found by the U. S. Biological Survey to have fed occasionally upon boll weevils. Most of these capture weevils during their period of spread in the fall of the year. Few birds occur in cotton fields until after the crop is laid by and their attack upon the weevil in the spring and early summer in insignificant. Among these birds the orioles have appeared to be the most abundant feeders on weevils during the summer months and the blackbirds and meadow larks during the winter months. Valuable as the quail is from other viewpoints it is not important as an enemy of the boll weevil. The quail feeds quite largely upon insects of various species as well as upon weed seeds, etc., and is entitled to the highest consideration as a beneficial and valuable game bird. The help of birds as well as of insect predators and parasites is welcome but not a certain dependable natural factor in boll weevil control.

Cultural Methods of Weevil Control More Certain.—After all that we have written about these most important factors in the natural control of the boll weevil we wish to emphasize the fact that they are to be considered only as additional to the far more certain control by artificial cultural methods. Natural control operates as surely, and it may be as largely, in addition to what the farmer is able to do for himself. It is possible for the farmer under average conditions to assure himself a good crop in spite of the boll weevil, so far as seasonal or climatic and soil conditions may

permit, but it is only by utilizing the factors of hard, intelligent and timely work and never by depending upon a kind Providence to do it for him while he loafs two-thirds of the time.

ESSENTIALS TO SUCCESSFUL WEEVIL CAMPAIGN

1. *Hold Farm Labor.*—This is a matter of the utmost importance as land without labor to work it becomes nonproductive and unprofitable. It is possible to keep labor on the farms and to readjust our farming system so as to minimize boll weevil damage and soon increased prosperity will be enjoyed. But if the labor once moves out of a community, the fields are allowed to become brushy, the unoccupied cabins decay rapidly, roads are neglected, the value of land goes down and it soon becomes a very difficult matter to get any good labor back into such a community. The sections which have suffered most heavily from the weevil invasion lost far more because they let their labor go than from any direct injury done by the weevils.

2. *Smaller Acreage and Better Cotton.*—Reduction in acreage planted in cotton to what can be given the better care that is absolutely required under weevil conditions is a long step toward success. The experience of large numbers of the most progressive and successful planters in old infested territory, especially where the rainfall is less than 16 inches during June, July and August, proves conclusively that cotton culture on a small scale can be continued profitably in spite of the boll weevils where such methods are followed as have been recommended in this bulletin.

3. *Increase Food, Forage and Livestock.*—It becomes necessary for the farmers to learn to raise as much as possible of their food and forage crops instead of depending upon the proceeds of their cotton crop to buy such foodstuffs. The reduced acreage in cotton leaves land available for such crops and for pasturage. We now know that Alabama farmers can produce as large a variety of such crops as can be grown in any state in the Union. Many of these crops, or combinations of crops which can be produced in a season in place of so much cotton, will yield a much higher margin of profit per acre than cotton has ever yielded even at a price of better than 12 cents per pound. Instead of sending out of the State possibly more than $100,000,-

000 a year for food and forage as we have been doing under the all-cotton system, most of this immense sum can be kept at home as Alabama learns to feed herself.

4. *Reducing Advances on Crop Liens.*—Necessarily for the protection and best interests of both the farmer and the advancing party these advances must be reduced in weevil territory. The reduction should be made gradually during a period of years to enable both parties to become accustomed to the new conditions and to institute such changes as are required thereby. Through it all there must be one common purpose to stand by each other loyally for the ultimate good of both parties. One imperative condition in these reductions is that they shall not be made complete at once or carried to such an extent as to seriously cripple the farmer in his production of farm crops or other desirable products. The tenant farmer or cropper must be willing to meet the land owner, merchant or banker at least half way in making these changes. Advances should be conditioned upon the farmer making such changes in his system of farming as the local situation may require. As a rule, he should assure at least the raising of all corn and meat needed to carry him through the year. Rental systems may be changed from a standing rental to a share system or from the usual two bales of cotton per plow to one bale of cotton and the equivalent value of the other bale in other acceptable farm products or in cash. Show the farmer that something beside cotton can pay his bills and it will not be so difficult to bring about needed changes.

5. *Maintain Total Value of Farm Products.*—With a diversified system of farming even the average man can be helped through wise leadership to at least maintain the total value of his farm products for the year. The chances are good that this total value will be greatly increased while his living expenses are actually decreased and the standard of living for the whole community may be steadily raised.

6. *Provide Markets For New Products.*—In the disposal of the surplus from these new farm products the farmer needs the assistance of some of the local business men who may help him to solve the problem of markets. Many such products can be disposed of locally. Merchants can act as buyers or agents to collect products in such quantities that they can be shipped in quantity to more distant markets. It should be

the purpose in such cases to return to the farmer the largest possible portion of the proceeds as the greatest good for the whole community will be accomplished by helping and encouraging the farmer during this critical period of change. Numerous associations of farmers to co-operate in the selling of their products are being formed as a result of this need for markets. In the moving of such products locally, the matter of reasonable and equitable local freight rates is an extremely important factor.

7. *Longer Leases.*—The annual lease system is a constant and serious hindrance to desirable changes and improvements. Wherever possible, as with many of the best tenants on a farm, the lease period should be extended to three or five years. The farmer can then know that it will benefit him to go ahead with his fall campaign against the boll weevil, to use winter-growing cover crops, to build up his soil, to raise live-stock, etc., as he will never do under the annual lease system. As a result the fertility of the soil can be most economically increased and at the end of the lease period the owner will have a more valuable piece of property than he would have under the annual system. Many large land owners are making this change.

8. *Improve Soil by Legumes and Livestock.*—The most economical, profitable and permanent system of farming includes both of these factors as essential elements in soil building. This is one of the most important elements in a successful campaign against the boll weevil as also in the solution of many of our southern rural problems. Many unprofitable fields might easily be converted into good permanent pastures with a combination of clovers and grasses, soil erosion can be checked, the commercial fertilizer bill can be greatly reduced and the real profit obtained from such fertilizers as are used can be increased as our farmers learn to increase the vegetable matter in their soils through the wise utilization of legumes and livestock.

9. *Alabama Must Feed Herself.*—Such changes will carry us a long way toward the fulfillment of this slogan. The coming of the boll weevil is helping us to realize the necessity for it as we never have before. Prosperity through the State as a whole will increase as we approach this standard, for the welfare of the

town and city, of the business and professional man as well, is ultimately conditioned upon, and largely measured by, the preceding prosperity of the farmer.

10. *Make Farm Life Satisfying.*—It is not enough, however, for us to look merely at the size or variety of farm crops or even at the amount of profit that the farmer may obtain from his year's work. We cannot fail to realize that this alone will never solve what we consider today as many of our most important rural problems. There must also be the enlarging of the life of those living on the farms. This means the improvement of the means of communication by better roads, rural mail deliveries, telephones, etc. There must be the improvement of the rural school facilities so that the children of the farmer may have within their reach practically as good common school training as is open to the young people of the town. Poor country schools have been the cause of more of our best, most intelligent and most successful farmers leaving the farms and moving into town than all other unsatisfactory country conditions combined. We cannot expect this loss to the country to be stopped until the country school is greatly improved. The country church is another important factor that cannot be overlooked. A high moral atmosphere is one of the most valuable assets of any community and certainly no less so in the country than it is in the town. There must be a higher development of its social life in the country community. And finally, but by no means least, the increased prosperity of the farmer must find expression also in the improvement of the farm home. Bethouses, neatly kept and painted, with more conveniences and comforts in them, for the housewife especially, but for every member of the household as well, will go far toward making the farm life attractive and satisfactory. The health of the family must be safeguarded especially through the maintainance of simple and inexpensive sanitary closets, thus helping to save on doctor's bills and making the farm home a healthier and happier place in which to live.

Strange as it may seem to many, the coming of the boll weevil is clearly and definitely helping to bring about progress along every one of these lines, and the campaign that is made against the weevil is the agency through which many of these more satisfactory changes for our country life shall be accomplished.